2c shows a singular construction of carbon fibres and thermoplastic powder. In both cases the delamination resistance and some toughening is provided by fibre bridging between the textile layers and the fibrous veil. However this is greatly enhanced by the presence of thermoplastic in the veil layer.

By appropriate design of the interply veil, the resin flow rate across the veil may be enhanced relative to the flow rate across the upper and lower structural layers and thus improve the rate of injected resin impregnation into the composite.

In both cases, the curing agent may be present with the structural components prior to the addition of the resin so that the curing process may be activated at the appropriate temperature once satisfactory "wetting" of the structural component has taken place.

Example 1

A composite was prepared from a fabric preform that consisted of glass fibres commingled with polypropylene fibres in a quadriaxial non crimp fabric. The fabric was impregnated with a low viscosity unsaturated polyester resin and the laminate was cured at room temperature followed by a post cure at 80°C in accordance with the resin supplier's specification.

The plate was 3 mm thick and the volume fractions of the three components as follows:-

glass fibres 0.2 v/v;

polypropylene fibres 0.2 v/v; and

polyester resin 0.6 v/v.

The laminate was subjected to a falling weight impact test to measure its energy absorption. The specific test configuration used produces absorbed energy results for glass fibre composites that fall in a master curve determined by the thickness of the laminate and the volume fraction of fibres.

The energy absorbed by the laminate prepared from the preform with polypropylene fibres added as toughening agents was 100 J.

In contrast, a similar laminate produced from identical polyester resin 0.8 v/v but reinforced with a fabric that was totally produced from glass fibres of a fibre volume fraction of 0.2 v/v and a thickness of 3 mm absorbed an average of approximately 40 J. This demonstrates that addition of the thermoplastic fibres into the preform provides a considerable toughness benefit.

Example 2

A glass fibre epoxy composite was prepared from a DGEBA epoxy resin (digylcidyl ether of bisphenol-A cured with an amine hardener [Shell Epikote 828 cured with Ciba HY932 aromatic amine]) and a plain weave woven fabric of E-glass fibres. The fabric occupied approximately 50% by volume of the composite. A similar composite was prepared with the same level of fabric but where the fabric component contained 70% (by volume) E-glass fibres and 30% by volume of a semi-crystalline polymeric fibre, with a crystalline melting temperature of 210°C.

The composites were produced by impregnating the fabrics and laminating to a thickness of 6cm thick and cured in an oven set at 190°C. Thermocouples embedded in the centre of the laminate monitored the temperature rise in the materials as they initially equilibriated to the oven temperature and then experienced further temperature rises due to the exothermic curing process.

The laminate with just glass fibres exhibited a temperature rise well beyond the 190°C oven temperature which became rapid and reached a peak value of 300°C at which point significant degradation of the epoxy was observed. The laminate with semi-crystalline thermoplastic fibre also exhibited a temperature rise due to the exothermic cure but once this temperature reached the crystalline melting temperature of the thermoplastic

fibres, the overall temperature rise was halted and the epoxy resin did not noticeably degrade.

Example 3

A carbon fibre composite, 3 mm thick, was prepared from a plain weave fabric and an epoxy resin (digylcidyl ether of bisphenol A cured with an amide hardener [Shell Epikote 828 cured with Ciba HY932 aromatic amine]). The fabric contained 70% by volume carbon fibres (Torayca T300) and 30% by volume nylon 6.6 fibres. The fabric was impregnated with the liquid epoxy resin and cured at room temperature for 24 hours followed by a post cure at 100°C for 4 hours. The cured laminate contained approximately 50% carbon fibres by volume and 21% of nylon fibres by volume. The remaining 29% of the composition was cured epoxy resin. A similar composite was prepared by impregnating a fabric produced exclusively from carbon fibres. In this case the plain weave carbon fibre occupied 50% of the volume of the composite and the epoxy resin matrix occupied the remaining 50%.

Both laminates were subjected to excess energy, falling weight impact tests. The laminate comprising just carbon fibres and an epoxy matrix absorbed 50 J of energy. The laminate with the carbon fibres, nylon fibres and epoxy matrix absorbed 85 J.

Examples 4 to 7

Tests have been conducted with a series of medium volume fraction glass fibre composites which exhibit impact toughness (energy absorbed during drop weight impact with full penetration) which is enhanced by a factor of 2-3 times by inclusion of thermoplastic fibres in comparison to the unmodified analogues. Tests have also shown a remarkable lack of sensitivity to notches in open hole tension tests on the same materials.

The impact results of two materials against two control samples are shown in Figure 3 and Table 1 defines the materials tested.